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Filter Element

The invention relates to a filter element comprising a filter medium, which extends between two end caps which are each connected to one assignable end area of the filter medium, which is supported at least on one side on a support tube.

Filter elements of the aforementioned type are conventional and are widely used for example in hydraulic systems in system branches through which hydraulic oils flow. The known filter elements are not entirely satisfactory with respect to their operating reliability and the stability of the beta value which is decisive for filter performance. In particular, for high flow rates there is the danger that at the connecting site at which the ends of the filter mat web are combined into a ring body which forms the filter cylinder, deformations or damage will occur due to the differential fluid pressure which is active at the connecting site. These adverse effects and/or deformations of the folds in the area of the connecting site are generally termed "buckling of the folds" in the technical terminology.

To counteract this, for example in the DE 102 50 969 A1 which was published at a later date, it was suggested that the sequence of folds for the filter medium of the filter element be selected such that each fold which extends over the entire radial extension of the intermediate space from the outer jacket surface to the inner support tube is followed by one fold with a radially inside

fold back located at a distance from the inner support tube of the element, and which is followed in turn by a fold which extends over the entire radial extension of the intermediate space. This yields improved beta value stability, even at high flow rates.

Furthermore, in the known solutions the structure of the filter media and filter elements can vary greatly from manufacturer to manufacturer. For simple paper elements the filter mats are made as filter media without supporting wire gauze, and at higher differential pressures on the filter elements the filter folds can be pressed together. This results in the drainage possibility for folded mats being reduced so that accordingly many folds remain unused for filtration. Conversely, higher quality elements have a multilayer mat structure for the filter medium, for modern filter media a six- and more layer structure indeed being possible, for example in the form of a succession of following layers; an outer support, a protective nonwoven layer, a prefilter layer, a main filter layer, a support nonwoven layer, and an inner support. Moreover, when the filter material is a filter mat web built up in several layers as described above, they have an outer support which forms the outer jacket surface in the form of a lattice or gauze structure. This can be a polyamide- or polyester-based structure and alternatively the multilayer filter mat web can have a metallic grating as the support which forms the outer jacket surface. The respective filter medium which is built up in several layers is also termed a mesh pack in the technical terminology, and generally the dirty fluid flows through it in one direction (often in general from the outside to the inside), the dirty components remaining in the filter medium.

To make the filter element stable under pressure, provision is moreover made such that in the interior there is a support tube, preferably of plastic material, which provided with perforations supports the filter medium against the intended flow direction. The two end caps between which the filter medium, and if necessary the plastic support tube extends, are likewise made preferably from plastic materials, especially the plastic support tube made as an injection molded part. Since the filter medium for fixing with the end caps is generally cemented to them in the area of its free ends,

the cement used, often in the form of an epoxy resin cement, produces a type of insulating layer between the inserted filter medium, the two end caps, and/or the support tube, the insulating effects being further intensified by the support tube being preferably made longer than the actual filter medium (mesh pack), so that forces cannot act on it in the longitudinal direction. If this application of force cannot be avoided, it is possible that as a result of the compressive stresses which occur when the fluid flows through the filter medium the latter is damaged and in this way then adequate filtration performance can no longer be ensured.

The indicated insulation structure, due to the insulating layers between the filter medium, the end caps, and the support tube, can cause electrostatic charging especially of the filter medium when fluid passes with dirt which may be present on the filter medium. Due to the potential differences which are produced in this way, within the filter element discharges can suddenly occur between statically charged filter element parts, especially in the form of the filter medium and electrically conductive components, especially in the form of the generally metallic filter housing in which the filter element is held, with the result that electrostatic discharges occur; this must be considered critical with respect to the combustibility of the media to be filtered, such as hydraulic oil, heavy oil fuels such as diesel fuels or the like, and the indicated electrostatic discharges can also lead to damage of the oil and of the sensitive filter medium material.

On the basis of this prior art, the object of the invention is to further improve the known filter elements while maintaining their advantages, specifically high operating reliability and high beta value stability, even at high flow rates on the medium to be filtered such that especially in operation of the filter element no potential differences can occur between parts of the filter element which lead to electrostatic discharges. This object is achieved by a filter element with the features specified in claim 1 in its entirety.

In that, as specified in the characterizing part of claim 1, at least one of the end caps and/or at least one end area of the filter medium has a contact-making means and/or the respective end cap itself or parts of it are made dissipative, for purposes of dissipating the electrostatic charges which occur especially in filter element operation by means of the fluid medium it is ensured that the charge which is generated by triboelectric effects on the filter medium (mesh pack) can drain by way of the contact-making means or the respective end cap to a ground point, for example formed from metallic housing parts in which the filter element can be held with formation of a filter device. As a result of this dissipation, voltage peaks within the filter element are avoided, with their adverse result that spark discharges can occur which could damage the filter element itself.

In one preferred embodiment of the filter element as claimed in the invention, provision is made such that the contact-making means consists of conductive contact elements which penetrate a cement bed (epoxy resin cement) which forms a type of insulating layer between the end cap and the end area of the filter medium accommodated by this end cap, and in this way come into dissipative contact with the filter medium. Preferably it is furthermore provided that the conductive contact elements consist of contact pins which make contact with the mesh pack with their one free end in the cement bed, and in the area of the other free end stand vertically upright on the respectively assignable end cap. With this solution the insulating layer consisting of the cement bed is bridged by contact elements in the form of contact pins, the latter being dimensioned such that in any case the thickness of the cement bed and production tolerances for the filter medium (mesh pack) for dissipating the charge potential are reliably penetrated. The charge prevailing in the filter medium can thus drain by way of this end cap to the housing as the ground point via the dissipative pins which are preferably injected together with the O-ring-shaped cap as the end cap of the filter medium, and breakdown of the charge with spark formation within the element is reliably prevented in this way.

In another preferred embodiment of the filter element as claimed in the invention, to form the dissipative end cap or its parts, plastics with a conductivity additive, conductive coatings, or intrinsically conductive plastics are used. High quality steel fibers, aluminum flakes, metal-coated glass fibers, or carbon fibers including conductive carbon black are especially well suited as conductivity additives for so-called filled plastics. Dissipative coatings can be applied galvanically or by high vacuum vapor deposition, by painting with conductive enamel or by means of flame, arc or plasma spaying. Furthermore, the application of nanolayers is conceivable here. Intrinsically conducting polymers (ICP) are plastics in which conductivity is achieved by doping. Plastics which are suitable for this purpose are especially polyacetylene, polypyrrole, polythiophene and polyaniline.

In another preferred embodiment of the filter element as claimed in the invention, the respective end cap has annular surfaces projecting to the inside and outside, between which the assignable end area of the filter medium fits, and the annular surfaces accommodate the contact-making means not only between themselves, but are also used as a lateral stop for the cement as soon as it is added to the end cap for a connecting process.

In another preferred embodiment of the filter element as claimed in the invention, at least that end cap with the contact-making means has a connecting part, for fixing the filter element in a filter housing, a sealing means, especially in the form of an O-ring which is located between the filter housing and the end cap of the filter element, being made dissipative. Due to the dissipative O-ring the filter element with its front surface need not necessarily be pressed against the housing which surrounds the filter element in order in this way to produce the necessary dissipative contact. Rather then in addition or alternatively a version of the filter element can be conceivable with a dissipative O-ring to discharge the potential difference.

Other advantageous embodiments of the filter element as claimed in the invention are the subject matter of the dependent claims.

The filter element as claimed in the invention will be detailed below using one exemplary embodiment as shown in the drawings. The figures are schematic and not to scale.

FIG. 1 shows in a partially cutaway state a longitudinal view of the filter element.

FIG. 2 shows a longitudinal section through the filter element as shown in FIG. 1.

The filter element as claimed in the invention has a filter medium 10 which extends between the two end caps 12, 14 which are each connected to an assignable end area 16, 18 of the filter medium 10 which is otherwise supported on the inner peripheral side on a support tube 20. Viewed in the direction of looking at FIG. 1, the lower end cap 14 has a contact-making means which is identified as a whole as 22 for dissipating an electrostatic charge which occurs in operation of the filter element in particular.

The contact-making means 22 consists of individual conductive contact elements, in particular in the form of individual contact pins 24 which extend through a cement bed 26 forming a type of insulating layer between the end cap 14 and the accommodated end region 18 of the filter medium 10, and in this way make dissipative contact with the filter medium 10. In this regard therefore the contact pins 24 penetrate the cement bed 26, and otherwise they stand vertically upright on the respectively assignable end cap 14 in the area of their other free end. This configuration can be provided fundamentally on the two end caps 14, 16; but placement on only on end cap is adequate in order in this way to ensure dissipation by way of this end cap 14 with the

ground points of the housing (not shown) in which the filter element can be held with the formation of a filter device.

As is to be seen in particular from the cutaway in FIG. 2, the filter medium 10 can be built up as a multilayer filter mat, for example with six layers, and the layers which follow each other in succession have the following:

an outer support, a protective nonwoven layer, a prefilter layer, a main filter layer, a support nonwoven layer, and an inner support, for the outer support a polyamide lattice or a polyester fabric being possible. The inner support of the filter mat can be supported on the outer periphery of the fluid-permeable support tube 20 or can be formed by this support tube 20 itself.

Since for reasons of weight and recycling it is a good idea to build up the entire filter element from plastic materials, this is accompanied by the problem of increasingly static charging as arises when the fluid to be filtered, for example as in this case from the outside to the inside, flows through the filter medium 10. In these cases then within the plastic filter element potential or charge differences arise with the result that when a definable charge difference is exceeded, sparkover or breakdown with the corresponding electrostatic discharge occurs. Since fundamentally the medium to be filtered is combustible, there is a risk in operation with pure plastic filter elements. Conversely, based on the contact-making means 22 with the contact pins 24 it is possible to discharge the potential differences and charges which occur by way of the end caps, especially the lower end cap 14, into the ground point which is formed by the housing, and statically relevant potential differences in addition to a electrostatic discharge are thus reliably avoided.

The filter medium 10 as shown in the figures is illustrated as a cylindrical filter mat; but the possibility also exists of making the individual filter mat layers pleated along a cylindrical periphery in order to increase the effective filter surface. A filter mat structure is also possible as is indicated

in DE 102 50 969 A1 which was published at a later date. When the filter medium 10 is being built up with its individual layers, it however should preferably be watched that they consist of correspondingly dissipative plastic materials. As is furthermore to be seen from FIG. 1 in particular, the respective end cap 12, 14 to the inside and outside is provided with one projecting annular surface 28 each, which integrate the cement bed 26 between themselves. Between the two annular surfaces 28 of the lower end cap 14 in turn the individual contact pins 24 extend in a parallel longitudinal alignment to the longitudinal axis 30 of the filter element. The conductive contact elements or contact pins 24 can consist of metal; but they are preferably made from a conductive plastic material which can be injected jointly with the end cap 14 in one working cycle.

Furthermore, the respective end cap 14 with the contact-making means 22 can have a connecting part 32 (compare FIG. 2) for fixing the filter element in a filter housing (not shown), one sealing means 34, for example in the form of a conventional O-ring which is located between the filter housing and one end cap 14 of the filter element, being made dissipative. Generally this O-ring would not have to be dissipative, since the filter element with its front surface 36 is pressed against the seating part of the filter housing by which conductive contact occurs. Accordingly it would however also be possible to effect the pertinent discharging via the O-ring of the sealing means 34 if the O-ring consists of dissipative material or is coated in this way. As is furthermore to be seen from FIG. 1, the contact pins 24 are configured in concentric circles to the longitudinal axis 30 of the filter element within the end cap 14, the imaginary circle which runs outermost has more contact pins 24 than the inner circle.

As is furthermore to be seen from the figures, within the support tube 20 along its ribs which border the fluid passage sites, a separating segment 38 is suspended or clipped accordingly at the connecting point 40, the individual separating walls 42 of this segment 38 enabling flow guidance within the filter element, in the direction of the penetration site 44 in the area of the lower end cap 14. In an extension to the top, the separating segment 38 has a plate-like closing body 48 which is

actuated by a compression spring 46 and which assumes the bypass function such that when the filter medium 10 is clogged, the uncleaned fluid can enter the interior of the filter element 10 via diametrically opposite entry points 50 in the upper end cap region 12, to flow through the filter element 10 and emerge in the direction of the lower penetration site 44, and the bypass function can be adjusted in terms of its triggering behavior by way of the definable spring force of the compression spring 46.

The indicated contact-making means 22 need not be limited to one solution in which the contact pins of one end cap or the end caps 12, 14 in the cement bed 26 make contact with the mesh pack, but it would also be conceivable for the necessary contact to be made via conductive mat webs in the form of a gauze or the like into which the cement penetrates. It would also be conceivable from the sides of the filter medium 10 to produce a conductive connection to the dissipative end cap areas, for example by corresponding wire or platinum connections (not shown).

With the solution as claimed in the invention it is in any case possible, even for pure plastic elements or for those filter elements which are made primarily of plastic materials, to reliably address the problem of static charging in addition to electrostatic discharge, without the modification having an adverse effect on the pressure stability values, beta values, filtration performance, etc.

As an alternative or in addition to the described contact-making means 22 however the respective end cap 14 itself or parts of it can also be made dissipative. To form the dissipative end cap 14 or its parts, plastics with a conductivity additive, conductive coatings or intrinsically conductive plastics are especially well suited. High quality steel fibers, aluminum flakes, metal-coated glass fibers, carbon fibers, but also conductive carbon black are well suited as conductivity additives for so-called filled plastics. Dissipative coatings can be applied galvanically or by means of high vacuum vapor deposition, by painting with conductive enamel, or by flame, arc or plasma

spaying. Furthermore, application of nanolayers is conceivable here. Intrinsically conducting polymers (ICP) are obtained preferably by doping, the following plastics being considered especially well suited for this purpose: polyacetylene, polypyrrole, polythiophene and polyaniline. This list is not conclusive.